

Technical Report 15-007

“Who do you know?”
Developing and Analyzing Entrepreneur Networks:
An Analysis of the Tech Entrepreneurial
Environment of Six African Cities

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**United States Military Academy
Network Science Center**

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Background

Our project introductory paper, “Network Models of Entrepreneurial Ecosystems in Developing Economies,” describes our team’s research goal of quantifying an influence network in this case, a local entrepreneurial ecosystem, in such a way that the analysis empowers decision-makers with the requisite knowledge to develop specific policy recommendations.

Additionally, another previous paper, “A Methodology to Develop Entrepreneurial Networks: The Tech Ecosystem of Six African Cities,” described our team’s modification of the Position Generator methodology developed by sociologists at the University of Groningen (Van der Gaag et al 2008) and how through the use of our innovative survey, we can aggregate each respondent’s input, forming a network model that accurately measures the entrepreneurial environment in a particular location.

This paper will focus on an initial descriptive analysis of the data our team collected in six different African cities. Details of our data collection visits are captured in the team’s paper entitled, “Who do you know? Developing and Analyzing Entrepreneur Networks: Data Collection in the Tech Entrepreneurial Environment of Six African Cities.”

Executive Summary

After experimenting with several data collection methodologies, we adapted the Position Generator technique mentioned above and then developed an innovative survey that we administered to almost 300 entrepreneurs in 6 African economic capitals. The survey captured the roles in the local ecosystem that the entrepreneurs indicated had the most influence. In order to assist in the classification and comparison of these networks, we developed a standardized list of roles for all

ecosystems. The standard roles are as follows:

1. Myself- The respondent can gain access to the required resource without any assistance.
2. Government Representative- A representative from any level of Government can assist with access to the required resource.
3. Government Business Development Program- A Government Program exists that can assist with access to the required resource. The team decided that we would separate Government Business Development Programs from Incubators sponsored by corporations or impact investors in order to differentiate between ecosystems that have a greater central government involvement than others.
4. Incubator- An Incubator exists that can assist with access to the required resource. We considered Incubators to be traditional business incubators, accelerators, or tech hubs. In some places that we visited, the entrepreneurial environment was not mature enough to support a traditional incubator model and the organizations tended to be a gathering spot for tech entrepreneurs and tech enthusiasts.
5. Non-Governmental Organization (NGO)- Any number of NGOs can assist with access to the required resource.
6. Local Investor- Any local Angel Investor or Venture Capitalist that can assist with access to the required resource.
7. Family Member- An immediate family member who can assist with access to the required resource.
8. Religious Leader- A local minister or other religious member who can assist with access to the required resource.
9. Someone in Social Network- Someone beyond an immediate family member, in network of friends, or a connection on social media who can assist with access to the required resource.
10. Commercial Bank- A staff member at a bank who can assist with access to the required resource.
11. White Collar Professional- White Collar Professionals were defined as attorneys, accountants, brokers, and anyone providing professional services who can assist with access to the required resource.
12. Military Leader- Any member of the military who can assist with access to the required resource.
13. Education Leader- A University Professor or any other leader in the education sector who can assist with access to the required resource.

Based on the collected data, the team then developed networks of influence that characterize each ecosystem. Our initial review and analysis of each network yields the following initial insights:

- The *Network, Self, and Professional Roles* tend to be the most influential roles in all networks.
- The *Incubator Role* is generally less influential than expected.
- The *Incubator Role* is considerably more influential in the Accra network than all others.
- The *Government Representative Role* has the most influence in both the Monrovia and Addis Ababa networks.
- In almost all networks, the *Military* and *Religious Roles* have no influence on the tech entrepreneurial ecosystem.
- *Commercial Banks* have very little influence on the entrepreneurial ecosystems.
- The *Non-Governmental Organizations Role* exhibited almost no influence in the networks except in the Monrovia and Lusaka.
- The *Local Investor Role* also exhibited limited influence in most networks.
- The *Professional Role* generally has influence in all of the Entrepreneurial Ecosystems although to varying degrees.

Country Political and Economic Backgrounds

The team believes that it is important to understand the political and economic background of each of the visited countries in order to more effectively analyze the developed networks. As a reminder, the cities were selected based on relationships we have fostered as a result of prior research work. Two of our most important relationships include: Jon Gosier, the founder of AfriLabs, a pan-African group of technology and innovation hubs promoting the growth and development of the African technology sector, and, Ben White, the co-founder of VC4Africa, a web-based platform for startup funding and the largest online community of entrepreneurs and investors dedicated to the African continent. Jon and Ben were instrumental in both suggesting survey sites and initiating coordination with the incubator and hub staffs.

Each of the six countries the team visited has diverse histories and cultures. This context is vital for our analysis because this background has been an important influence on the current entrepreneurial ecosystems. This section will provide short synopsis of each country in the order in which we visited. Each summary is a synthesis of information from the Central Intelligence Agency's World Factbook as well as the State Department's country summaries provided by the U.S. Embassy staffs.

Uganda

Uganda achieved independence in 1962. The dictatorial regime of Idi Amin (1971-79) was responsible for the deaths of some 300,000 opponents and human rights abuses. Under his successor, Milton Obote (1980-85) at least another 100,000 lives were lost. Yoweri Museveni succeeded Obote in 1986 and under, essentially, his one-party rule Uganda has enjoyed relative stability and economic growth.

New economic reforms have resulted in solid economic growth with a focus on investment in infrastructure, incentives for production and exports, lower inflation, and improved domestic security. Oil revenues and taxes are expected to become a larger source of government funding as oil comes on line in the next few years. Unreliable power, high energy costs, inadequate transportation infrastructure, and corruption inhibit economic development and investor confidence. The country also faces challenges including troubled 2011 parliamentary and presidential elections, continued rapid population growth, human rights problems, corruption, and inflation. Uganda is a key U.S. regional strategic partner through both its involvement in the African Union Mission in Somalia and counter-Lord's Resistance Army efforts in central Africa.

The local tech environment is very vibrant with four active existing hubs that are sponsored by impact investors and corporations. Hive CoLab is the most well known and established. All hubs are working to improve their business models in order to achieve sustainable models. Since our visit, Mara Launchpad has drastically changed its operating model.

Ethiopia

Ethiopia is unique among African countries in that the ancient Ethiopian monarchy maintained its freedom from colonial rule with the exception of a short-lived Italian occupation from 1936-41. In 1974, a military junta known as "the Derg," deposed Emperor Haile Selassie, who had ruled since 1930, and then established a socialist state. Torn by bloody coups, uprisings, wide-scale drought, and massive refugee problems, the regime was finally toppled in 1991 by the Ethiopian People's Revolutionary Democratic Front (EPRDF). A constitution was adopted in 1994, and Ethiopia's first multiparty elections were held in 1995. Even though, it is a multi-party system, Ethiopia is essentially ruled by the EPRDF.

The government unveiled a five-year Growth and Transformation Plan in 2010. This plan is an ambitious government-led effort to achieve the country's development goals. According to the US State Department, Ethiopia has attracted significant foreign investment in commercial agriculture and manufacturing. However, the finance, insurance, and micro-credit industries are restricted to domestically-owned firms.

Ethiopia's constitution mandates that the state owns all land and, subsequently, provides long-term leases to the tenants. The government has started to issue land use "certificates" so that tenants have some type of recognizable rights to continued occupancy. While GDP growth has remained high, per capita income is among the lowest in the world.

The tech environment in Addis Ababa, the capital, was still in its nascent stages during our visit. iceaddis, the best known hub, had also modified its operating model to adjust for the lack of maturity of the local entrepreneurial environment.

Zambia

Zambia gained its independence in 1964 from the United Kingdom. Zambia saw single-party rule from independence until 1973, when it formally became a one-party state. In 1991, elections replaced Kenneth Kaunda, the country's first president, who served for over 27 years. These elections brought an end to one-party rule and introduced a more liberalized economy.

The Zambian Government is pursuing an economic diversification program to reduce the economy's reliance on the copper industry. Zambia's economy has experienced strong growth in recent years, with real GDP growth in 2005-12 more than 6% per year. Privatization of government-owned copper mines in the 1990s relieved the government from covering mammoth losses generated by the industry and greatly increased copper mining output and profitability to spur economic growth. Zambia has made some strides to improve the ease of doing business.

The tech environment in Lusaka, Zambia's capital, is also still emerging. BongoHive is the leading and best known incubator/hub in Lusaka. At this time, there are not any other similar types of organizations in Lusaka.

Liberia

Between 1821 and 1838, a group called the American Colonization Society settled freed slaves in what is now Liberia. In 1847, the colony was proclaimed the Republic of Liberia. At the time it had a population of approximately 3000 Americo-Liberians as well as the indigenous population. A constitution was drawn up along the lines of that of the United States.

Between 1847 and 1980, the Americo-Liberian minority governed Liberia. They created a society that maintained their English-speaking, Americanized way of life. William Tubman, Liberia's President from 1944-71, did much to promote foreign investment and to bridge the economic, social, and political gaps between the descendants of the original settlers and the inhabitants of the interior. However, in 1980, a military coup led by Samuel Doe ushered in a decade of authoritarian rule. In December 1989, Charles Taylor launched a rebellion against Doe's regime that led to a prolonged civil war in which Doe was killed. An August 2003 peace agreement ended the war and prompted the resignation of former president Charles Taylor, who faces war crimes charges in The Hague related to his involvement in Sierra Leone's civil war. After two years of rule by a transitional government, democratic elections in late 2005 brought President Ellen Johnson Sirleaf to power. She subsequently won reelection in 2011 and remains challenged to build Liberia's economy and reconcile a nation still recovering from 14 years of fighting.

The tech environment in Liberia's capital, Monrovia, is also still in its nascent stages mainly due to the continuing recovery from a long period of civil war. United Nations Peacekeepers are still noticeably present in the capital and there appeared to be

a much stronger influence of Non-Governmental Organizations. Due to the local conditions, the incubators and hubs are challenged by limited internet bandwidth and intermittent power. Despite these challenges, four fairly vibrant incubators/hubs have established themselves in Monrovia.

Ghana

Ghana has emerged as a leading economy on the African continent. Ghana endured a series of military coups after independence in 1957 but a multi-party political system was established in 1992 under a new constitution. Since 2000, Ghana has had enjoyed political stability with 4 successful presidential elections which have also included changes in ruling parties.

Ghana's Gross Domestic Product (GDP) grew at 14 percent in 2011 and annual GDP growth through 2015 is projected at least 7 percent, placing Ghana seventh in the International Monetary Fund's ranking for the world's fastest growing economies. A number of major U.S. companies operate in the country. Recently, the discovery of major oil reserves in the Gulf of Guinea has led numerous international petroleum exploration firms to enter the Ghanaian market and the potential economic windfall is enormous.

The capital city of Accra's entrepreneurial environment was the most vibrant and mature of all those I visited. There are three well-known incubators/tech hubs that are sponsored my international corporations and impact investors. Recently, a prominent messaging start-up, Saya, was acquired by a US mobile service company. Previous acquisitions of tech start-ups in Sub-Saharan Africa have been rare. Most economic development experts tout Ghana's great economic potential due to its political stability, overall sound economic management, low crime rate, competitive wages, and an educated, English-speaking workforce.

Tanzania

The United Republic of Tanzania was formed shortly after achieving independence from Britain in the early 1960s. The first President of Tanzania, Julius Nyerere, established a single party (Chama Cha Mapinduzi—"Party of the Revolution" or CCM) government dedicated to the idea of African Socialism and adhering to a vision of *ujamaa* ("unity", "oneness" or "familyhood"). Unfortunately, the socialist policies led to an economic decline. In the early 1970s, a collectivization policy was implemented and led to agricultural shortages and social unrest.

One-party rule ended in 1995 and the first democratic elections were held in the country since the 1970s. Tanzania has largely completed its transition to a liberalized market economy, though the government retains a presence in sectors such as telecommunications, banking, energy, and mining. In recent years, Tanzania has achieved high overall growth rates; the GDP growth rate has hovered between 6-7% over the last 4 years, despite the worldwide recession. This continued growth has been attributed to

improved macroeconomic policies (effective fiscal stimulus and loosened monetary policy), increased gold production, growth in tourism, and continued donor assistance. Interestingly, all land in Tanzania is still owned by the government, which can lease land for up to 99 years. Recent proposals to allow for land ownership, particularly foreign land ownership, remain unpopular.

There are three prominent incubators/tech hubs with a few new hubs recently established. Interestingly, one of the main incubators/hubs (Dar Teknohana and Buni) is sponsored by the Tanzanian government; the only government-sponsored incubator that we have encountered during our data collection visits. The other prominent incubator is sponsored by impact investors. The Mara Foundation had also established an incubator, but like in Kampala, they have recently modified the operating model.

Analysis: Network Models

Over the course of six visits, we were able to interview 266 local entrepreneurs. The methodology described in “*Who do you know? A Methodology to Develop Entrepreneurial Networks: The Tech Ecosystem of Six African Cities*,” enabled the team to develop each network model.

In summary the team developed matrices that captured the number of times that each entrepreneur answered a specific role to one of the six survey questions. We then utilized a technique commonly referred to as “data folding.” This technique takes the original two-mode network (survey respondents and roles) and converts it to a single-mode network. In this case, it illustrates how the roles are connected through the respondents’ perceptions of the local environment and also captures the weighting of the number of times that the respondent answers a survey question citing a specific role.

Figures 1, 2, 3, 4, 5 and 6 illustrate the network models developed in chronological order: Kampala (March 2013), Addis Ababa (May 2013), Lusaka (August 2013), Monrovia (November 2013), Accra (May 2014), and Dar es Salaam (August 2014). These network models were developed using the ORA network analysis software package developed at the Center for Computational Analysis of Social and Organizational Systems at Carnegie Mellon University. The links in each network model are weighted according to the strength of the relationship.

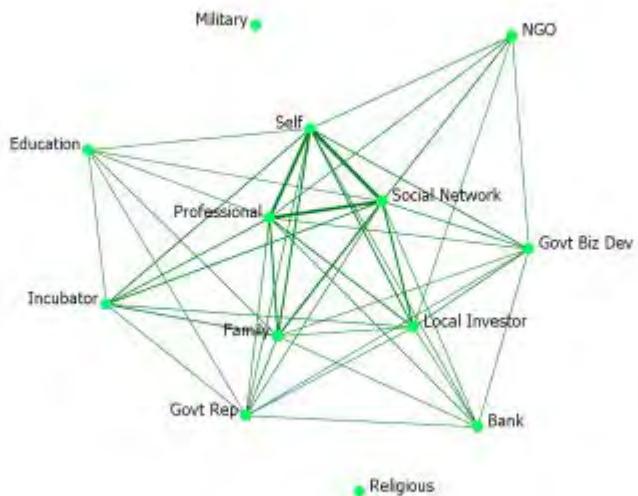


Figure 1: Kampala Entrepreneurial Ecosystem Network Model

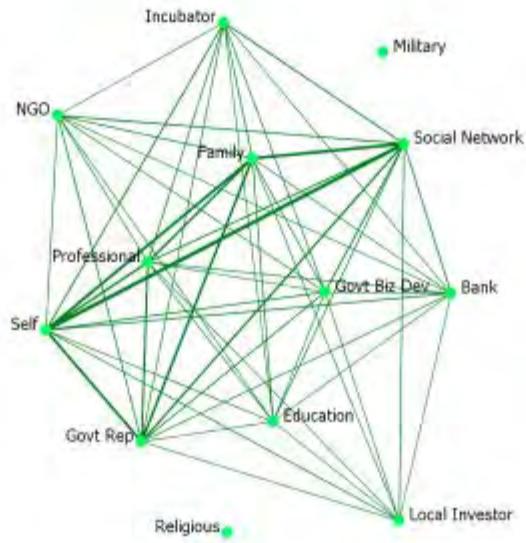


Figure 2: Addis Ababa Entrepreneurial Ecosystem Network Model

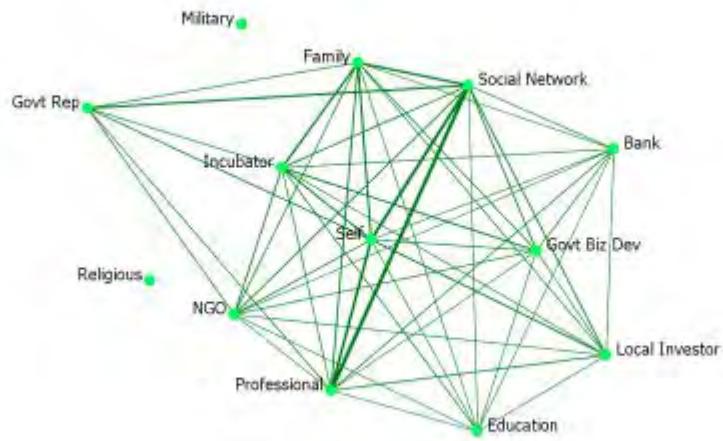


Figure 3: Lusaka Entrepreneurial Ecosystem Network Model

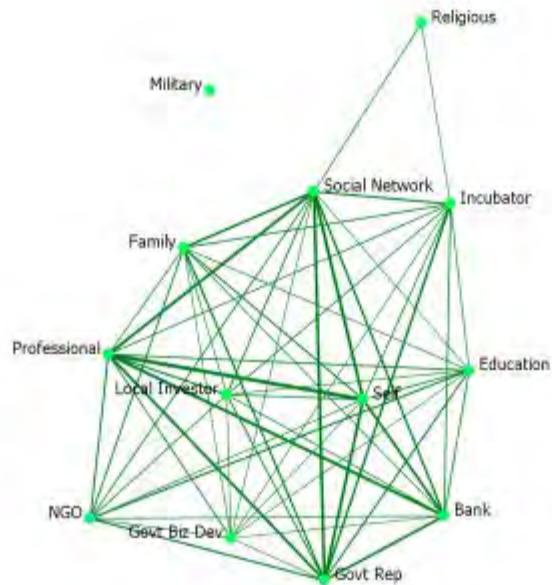


Figure 4: Monrovia Entrepreneurial Ecosystem Network Model
Note: Monrovia is the only network in which the Religious Role is linked.

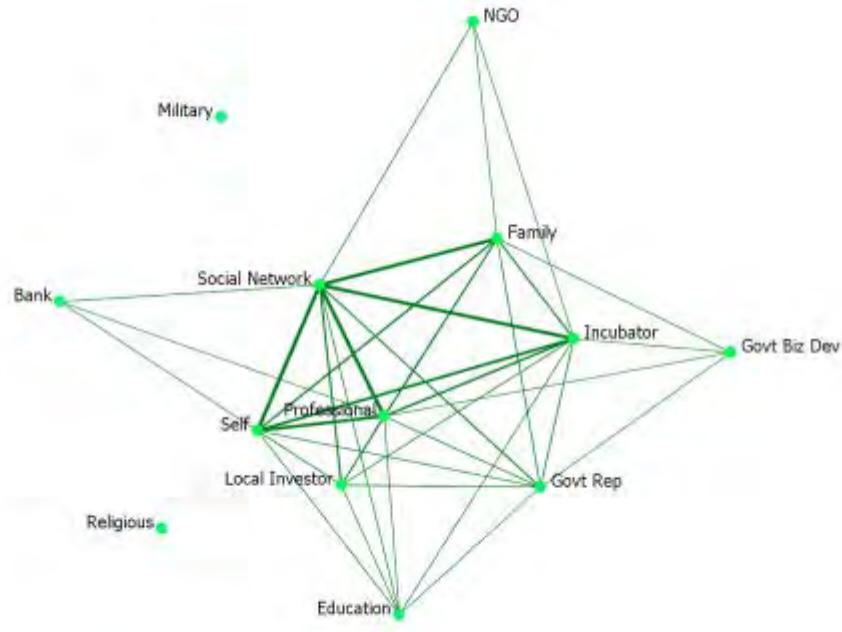


Figure 5: Accra Entrepreneurial Ecosystem Network Model

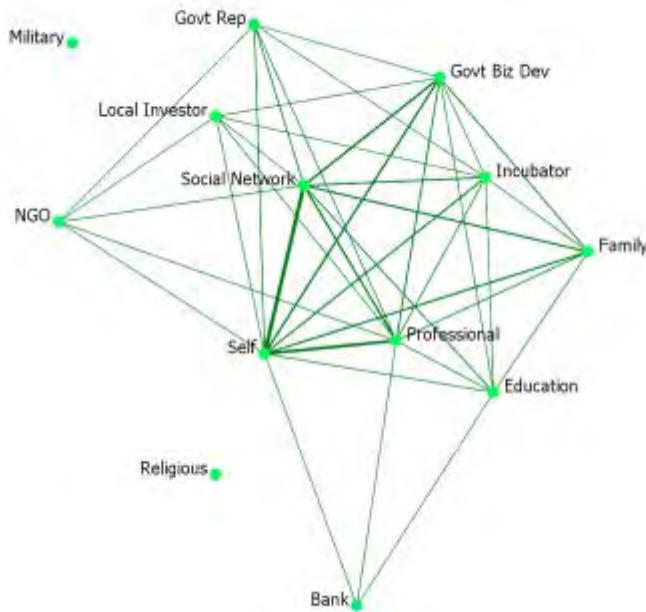


Figure 7: Dar es Salaam Entrepreneurial Ecosystem Network Model

Analysis: Network-Level Measures

For our initial comparison of these six network models, we will focus on network-level measures, or mathematical properties of the network as a whole. These network-level measures provide general indicators of network structure and are typically used as an initial comparison method when looking at multiple networks. Table 1 compares several commonly-used network-level metrics.

	Density	Link Count	Average Distance	Clustering Coefficient
Addis Ababa	.964	53	3.964	.968
Lusaka	.927	51	2.863	.952
Monrovia	.848	56	2.424	.955
Kampala	.818	45	2.418	.885
Accra	.673	37	3.018	.848
Dar es Salaam	.500	39	3.964	.702

Table 1: Network-level Metric Summary (Sorted by Density)

Density: The ratio of the number of links in the network compared to the total number of possible links the network. A network in which all nodes are connected has a density of 1.

Link Count: Simply calculated by counting the existing links between all pairs of nodes in the network. This measure is a convenient measure to initially compare networks.

Average Distance: Calculated by finding the shortest path between all pairs of nodes and the determining that average. This measure illustrates the average number of steps it takes to travel from any node to another in the network.

Network Clustering Coefficient: The average of each node in the network's clustering coefficient. Each individual node's clustering coefficient captures the degree, which that node's neighbors (one degree away) are connected to each other. For example, a node whose neighbors are all connected has a clustering coefficient of 1. A node with no neighbors connected has a clustering coefficient of 0. This is another measure useful for initial comparison of networks.

Network-level Metric Insights

Network-level Densities: Visually, we can separate the six networks into three separate groups. Addis Ababa (.964) and Lusaka (.927) have densities greater than 90%. Monrovia (.848) and Kampala (.818) have densities between 80% and 90%. While Dar

Dar es Salaam (.500) and Accra (.673) have densities lower than 80%.

Network-level Link Counts: We might expect that Link Counts will correlate closely with Densities. This is generally true but Monrovia which has the third highest density has the highest number of links in the network (56). Additionally, Dar es Salaam which has the lowest network density has a larger number of links than the next densest network, Accra (39 vs. 37).

Average Distances: The Average Distance values give a bit different picture. In this case, the most dense network, Addis Ababa, and the least dense network, Dar es Salaam, both have the largest number of average steps from any node to another (3.964). The networks with the lowest Average Distance are Kampala (2.418) and Monrovia (2.424) which were in the middle grouping in terms of network density.

Clustering Coefficient: We would also expect that Clustering Coefficient values will correlate closely with Densities. Once again, this is generally true with the exception of the Monrovia network which has a slightly higher Clustering Coefficient than Lusaka (.955 vs. .952)

Analysis: Node-Level Measures

While network-level measures yield interesting insights concerning the characteristics of networks, we believe that node-level measures will produce insights that are more actionable for policy developers and decision makers. These network analysis techniques enable us to quantitatively characterize the individual nodes in each network. For our initial analysis, we will focus on a common node central measure referred to as Degree Centrality. Degree Centrality is a measure of how important or influential a node is based on the number of connections a node has in comparison to the total possible number of connections in the network. Nodes that are high in degree centrality tend to be in the center of the network graph.

Table 2 is a summary of the Degree Centrality metrics by city and Table 3 is a summary of the Degree Centrality metrics by Role across all six networks:

Accra	Addis Ababa	Dar es Salaam			
Social Network	0.4379	Self	0.3450	Self	0.2936
Self	0.2985	Social Network	0.3162	Social Network	0.2723
Professional	0.2818	Family	0.2900	Professional	0.1691
Incubator	0.2470	Govt Rep	0.2375	Govt BizDev	0.1266
Family	0.1955	Professional	0.1700	Family	0.1011
Investor	0.0909	Govt BizDev	0.0775	Incubator	0.0734
Govt Rep	0.0727	Incubator	0.0725	Education	0.0372
Education	0.0227	NGO	0.0600	Govt Rep	0.0298
Govt Biz Dev	0.0076	Commercial Bank	0.0538	NGO	0.0160
NGO	0.0076	Education	0.0375	Investor	0.0160
Commercial Bank	0.0076	Investor	0.0250	Commercial Bank	0.0053
Kampala	Lusaka	Monrovia			
Social Network	0.3215	Social Network	0.3513	Govt Rep	0.4132
Self	0.2954	Self	0.2846	Professional	0.4050
Professional	0.2646	Professional	0.2513	Social Network	0.3802
Family	0.1508	Family	0.2077	Self	0.3664
Investor	0.1092	Incubator	0.1769	Commercial Bank	0.2893
Incubator	0.0892	Govt BizDev	0.1000	Family	0.1846
Govt BizDev	0.0508	NGO	0.1000	Incubator	0.1680
Govt Rep	0.0385	Investor	0.0974	NGO	0.1625
NGO	0.0385	Govt Rep	0.0949	Education	0.1377
Commercial Bank	0.0231	Commercial Bank	0.0513	Investor	0.1322
Education	0.0154	Education	0.0385	Govt Biz Dev	0.0413

Table 2: Node-level Metrics Summary-Degree Centrality (by City)

	Social Network	Self	Professional	Incubator	Family	Investor
Accra	0.4379	0.2985	0.2818	0.2470	0.1955	0.0909
Addis Ababa	0.3162	0.3450	0.1700	0.0725	0.2900	0.0250
Dar es Salaam	0.2723	0.2936	0.1691	0.0734	0.1011	0.0160
Kampala	0.3215	0.2954	0.2646	0.0892	0.1508	0.1092
Lusaka	0.3513	0.2846	0.2513	0.1769	0.2077	0.0974
Monrovia	0.3802	0.3664	0.4050	0.1680	0.1846	0.1322
	Govt Rep	Education	Govt Biz Dev	NGO	Bank	Religious
Accra	0.0727	0.0227	0.0076	0.0076	0.0076	0.0000
Addis Ababa	0.2375	0.0375	0.0775	0.0600	0.0538	0.0000
Dar es Salaam	0.0298	0.0372	0.1266	0.0160	0.0053	0.0000
Kampala	0.0385	0.0154	0.0508	0.0385	0.0231	0.0000
Lusaka	0.0949	0.0385	0.1000	0.1000	0.0513	0.0000
Monrovia	0.4132	0.1377	0.0413	0.1625	0.2893	0.0138

Table 3: Node-level Metrics Summary-Degree Centrality (by Role)

The centrality metrics are normalized from 0 to 1; this enables us to effectively compare the nodes within each city network. Additionally, because each city network has the same number of nodes we can compare across city networks. For example, an analysis of degree centrality indicates that the Family Role is approximately twice as influential as the Investor Role (.1955 to .0909) in the Accra Network. The Incubator Role in the Accra Network is approximately three times (3x) as influential as the Incubator Role (.2470 to .0725) in the Addis Ababa Network.

Initial Insights:

From the analysis of these node-level measures, we can know better understand the influence of the network roles in each entrepreneurial ecosystem. With this knowledge, economic development specialists can more effectively assess and analyze each ecosystem. The following paragraphs introduce just some initial insights. However, the data set is extremely ripe for analysis at multiple levels and many diverse approaches.

The Network, Self, and Professional roles tend to be the most influential roles. However, Monrovia is very different from the other networks. Its most influential role is Government Representative. We surmise that the Government role might have greater influence based on the fact that Liberia is still emerging from the ravages of a brutal civil war. There is still a very large UN Peacekeeper presence and great reliance on NGO's in the country. It is interesting to note that NGOs are almost twice as influential in the Monrovia network as the next closest city, Lusaka (.1625 vs. .1000) and over twenty times (20x) as influential as in the Accra network.

The Incubator Role is generally less influential than expected. It is only the fourth most important role in the Accra Network (.2470 vs. .4379 for Social Network) and is moderately influential in both the Lusaka (half as influential as the most influential role) and Monrovia (less than half as influential as the most influential role) networks. The incubators had minimal influence in the Addis Ababa, Dar es Salaam, and Kampala Networks. For example the most influential role in the Addis Ababa network, Self, is almost five times (5x) as influential as the Incubator role.

The Government Representative role has the most influence in both the Monrovia and Addis Ababa networks (.4132 and .2375). Government Representatives are almost two time (2x) influential in Monrovia as in Addis Ababa and four times (4x) as influential in Monrovia as in Lusaka (.0949), the third-ranked network for influence of Government Representative.

In almost all networks, the Military and Religious roles have no influence on the tech entrepreneurial ecosystem. Monrovia is the only network that indicates the influence of Religious Leaders on the ecosystem.

Commercial Banks have very little influence on the entrepreneurial ecosystems. Anecdotally, we know that it is very difficult to secure business loans from commercial banks in Frontier Markets. Collateral is required, the loan standards are very rigorous, and interest rates are extremely high (20-30% in Ghana). Interestingly, Monrovia is once again an outlier. Commercial Banks appear to have major influence in the ecosystem. The most influential role, Government Representative, is only 1.5 times as influential as Commercial Banks. For comparison, in Accra, the most influential role, Social Network, is almost sixty times (60x) more influential than the Commercial Bank Role.

The Incubator Role is considerably more influential in the Accra network than all others. It is 1.4 times more influential than the Incubator Role in the Lusaka network, the network in which the Incubator role has the next highest influence (.2470 vs .1769). We hypothesize that this could be expected based on the maturity and effectiveness of the incubators that I visited in Accra. The Incubator Role may have had a similar influence in the Dar es Salaam network but as stated, we differentiated between government-sponsored and non government-sponsored hubs. In Dar es Salaam, the Government Business Development role was fairly influential, .1266. This is to be expected based on the influence of the only government-sponsored incubator that we came across, the Dar Teknokhama Business Incubator. Interestingly, the Government Business Development role has minuscule influence in the vibrant Accra Network (.0076).

The Non-Governmental Organizations role exhibited almost no influence in the networks except in the Monrovia (.1625, almost as influential as the Incubator role) and Lusaka (.1000, 3x as influential as NGOs in Kampala) network models. Our team surmises that based on the recent history of Liberia, the strong influence of NGOs is understandable. We don't know enough to explain NGO influence in Lusaka.

The Local Investor role also exhibited limited influence in most networks. Once again, Monrovia is an outlier. The Local Investor Role is over five times (5x) more influential in the Monrovia Network than the Addis Ababa Network.

The Professional role generally has influence in all of the Entrepreneurial Ecosystems although to varying degrees. For example, in Monrovia, the Professional Role is ranked second in terms of influence and in Dar es Salaam, the Professional Role is ranked third in terms of influence but the Monrovia Professional Role is over twice as influential in the network (.4050 vs..1691).

An Analytical Challenge

The survey data that we collected is weighted because we “count” the number of times a respondent selects a particular “position or role” in response to a survey question. This is problematic when we use the “data folding” technique because it involves matrix multiplication and the resulting values in the new matrix exaggerate the

scale of the relationships between the nodes. A relationship that is nominally strong in the original two-mode matrix receives a profoundly higher weighting in the final Role by Role matrix.

A network analysis technique commonly used to avoid this issue is to binarize the data (links either exist or they don't; one or zero) prior to folding the network. Because the survey instrument captures the number of times a respondent selects a particular role, this technique would lose the strength of the relationships between the roles in the entrepreneurial environment under analysis.

As our project progresses, we will explore other analytical techniques in order to more accurately portray the nodes' influence and the strength of the relationships. Some of these techniques will include several "projection techniques" which are quantitative techniques that utilize additive instead of multiplicative techniques in order to better convey the true information in regards to tie or link-strength in the network.

Conclusion

Despite, the analytical challenges discussed above, we believe that this methodology accurately captures the influential roles in the ecosystem under study. Due to resources, we were limited in the number of interviewers on each visit as well as time allowed on at each interview site. The results from this methodology will only be improved with an increase of the number of interviews and refinement of our collection process.

We will collect similar data from three other entrepreneurial environments in emerging economies. Once these network models are completed, our team will develop a quantitative technique that will enable the classification of each network. Based on this classification technique, we will be able to state, quantitatively, whether the networks are the same or if they are different and what quantitative differences exist.

As previously stated, we will then quantitatively compare the networks with the "goal network" and mathematically determine the nodes in the "network of interest" which are potentially the "driver nodes." These "driver nodes" are nodes that can be influenced in order to make network outcomes more socially desirable (Barabasi, 2011). The quantitative findings from this methodology will determine specific policy recommendations for each network based on its own specific centrality metrics. This methodology also develops a strong foundation for future economic development simulation exercises.

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